International Journal of Agricultural Science and Research (IJASR)
ISSN (P): 2250-0057; ISSN (E): 2321-0087
Vol. 5, Issue 4, Aug 2015, 235-246

STUDY ON GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR YIELD AND YIELD ATTRIBUTING CHARACTERS IN CLUSTER BEAN [*CYAMOPSIS TETRAGONOLOBA* (L.) TAUB.]

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ABSTRACT

An experiment was carried out on cluster bean to find out the study on genotypic variability, heritability and genetic advance expressed as percentage of mean for yield and yield attributing characters in thirty genotypes of cluster bean collected from different sources and maintained at the Horticulture Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India. The research findings showed wide range of variability for plant height (55.69-109.02 cm), pod yield per plant (79.24-122.17 g), number of pods/plant (41.07-76.73), number of clusters/plant (7.00-31.13), pod yield (120.29-143.50 q/ha) and number of pods/cluster (2.93-21.47). The genotypic and phenotypic variances were high for days to maturity (43.11-43.22) and germination percent (40.92-41.71). Heritability was high for number of pods/cluster (97.50 %) and number of clusters/plant (95.30 %), whereas, it was lowest for pod width (26.80 cm), high heritability combined with high genetic advance expressed as percentage of mean for number of pods/cluster (125.15 %), number of clusters/plant (84.44 %) and number of reproductive branches/plant (31.72 %). The characters like- number of pods/cluster, number of clusters/plant, number of reproductive branches/plant, plant height (cm) and pod yield/plot (kg), showed high genotypic coefficient of variation as well as high phenotypic coefficient of variation with genetic advance, indicating there by that selections based on phenotypic performance could be effective for improvement of these characters.

KEYWORDS: Cluster bean, genetic variability, correlation coefficient, path analysis, GCV, PCV and genetic advance

INTRODUCTION

Cluster bean or guar bean is botanically called as [*Cyamopsis tetragonoloba* (L.) Taub.] belongs to family Leguminosae is an annual legume vegetable crop. It is a self pollinated crop with diploid chromosome number 2n= 14. It is also known as gawaar in Hindi & Marathi, Goruchikkudu kaya or Gokarakaya in Telugu, Gorikayie in Kannada and Kotthavarai in Tamil reported by **(Vahrehvah.com, 2012)**. Guar also known as cluster bean is a drought hardy and warm season leguminous crop. It is being grown for seed, is an annual plant, about 4 feet high, vertically each pod is about 5-8 cm long and has seeds. The pods are used as a green vegetable or as a cattle feed besides extraction of guar gum in accordance with by **(Kumar and Hissaria, 2009)**. Guar is one of the most important and potential vegetable cum industrial crop grown for its tender pods for vegetable purpose and for endospermic gum [30-35%]. Tender pods are

nutritionally rich in energy (16 Kcal), moisture (81 %), protein (3.2 g), fat (1.4 g), carbohydrate (10.8 g), vitamin A (65.3 IU), vitamin C (49 mg), calcium (57 mg) and iron (4.5 mg) for every 100 g of edible portion by **(Kumar and Singh, 2002)**. The world's total production of Cluster bean is around 7.50 to 10.00 million tonnes at every year. The production list of guar is dominated by India as a leading producer of this crop. The consumption pattern of guar seeds is largely influenced by the demands from the petroleum industry of United States of America and the oil fields in the Middle East as the derivative products of these seeds are quite useful in the petroleum drilling industries. United States alone constitute to around 40 thousand tons of guar and its derivatives demand. Also, in rest of the world, the trend of consumption has increased with time that has lead to the introduction of this crop in many countries. The Major guar producing countries in the world are India, Pakistan, Sudan, USA, South Africa, Brazil, Malawi, Zaire and Australia. India leads the list of the major guar producing countries of the world contributing to around 75 to 80 % in the world's total production of around 7.5 to 10 million tonnes. Pakistan follows India in the list with 10 -15% share in the world's total produce. The most important by-product of this crop i.e. guar gum is obtained through the processing of endosperm of the seeds of guar. This product is vastly produced in the countries such as USA, Germany, China, Italy, South Africa, and United Kingdom though these countries are not really indulged in the production of guar as a crop suggested by **(Anonymous, 2012).**

India is the largest producer of guar in the world, which contributes to 80% of the total production. The average production of Guar seed in the country is 7.0 to 8.0 million tonnes and fluctuates largely from year to year based on rainfall pattern. India is also the largest producer of guar gum products. Guar seed production has declined to 8.5-9.0 million tons in 2008-09 against 10.5-11.0 million tonnes in 2007-08. Carry overstocks of last year are around 2.5 3.0 million tonnes. Thus, total supplies for 2008-09 stands at about 12.0 million tonnes in the current crop season between October 2008 and September 2009 reported by **(Anonymous, 2011).**The major cluster bean producing regions of this crop in India are Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Maharashtra, Karnataka, and Andhra Pradesh. Rajasthan can be termed as the largest guar producing state in the world as it dominates the Indian production scenario contributing to around 4.20 million tons of this crop i.e. over 70% of the total production in India. Haryana and Gujarat place themselves at the second and third positions regarding the production in India with 12% and 11% respectively. The magnitude of variability is measured in terms of genotypic coefficient of variation, phenotypic coefficient of variation and environmental coefficient of variation. Therefore, for rational improvement of crop, understanding of the magnitude of genetic variability and the extent to which the desirable characters are heritable becomes essential. The determination of genetic variability and its partitioning into various components is necessary to have an insight into the genetic nature of yield and its components. Study of partitioning the total variability into heritable and environmental components had its beginning in the work of **(Johanson, 1909), (Nilson-Ehle, 1909) and (East, 1916).** Based on the study on non-segregating populations, **Charles and Smith, (1939), Powers, (1942)** separated genetic variance from total variance using estimate of environmental variance. The magnitude of variability and its genetic components are the most important aspects of breeding material. Hence, basic understanding of the genetic variability is a prerequisite for the planning of breeding programme. A great deal of information has been generated on genetic variability of various components of cluster bean. Generally, genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) are measured to study the variability. The knowledge of nature and magnitude of genetic variability, heritability and genetic advance over mean for vegetable pod yield and component character are useful for an effective selection programme. Therefore, the present investigation is an attempt towards understanding of these genetic parameters, which

form an integral part of a programme for making improvements in different component traits and ultimately complex character vegetable pod yield in cluster bean by **Rai *et al,* (2012).**

MATERIALS AND METHODS

The present investigation was carried out at the Horticultural Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road Lucknow (U. P.), India during *Kharif* season of March, 2013 to July, 2013, in well levelled field having proper drainage. Geographically, BBA University, Lucknow is situated at an elevation of 123 meters above the mean sea level in the subtropical tract of central Uttar Pradesh at $26^0$76' North latitude and $80^0$92' East longitude. The place experiences winter and very hot summer with average rainfall. Agro climatically, the location represent Central Zone of the state of Uttar Pradesh, India, and is characterized by sub-tropical climate. The experimental material comprising of thirty genotypes of cluster bean was collected from different sources and maintained at the Horticultural Research Farm, Babasaheb Bhimrao Ambedkar University, Lucknow. All recommended package of practices were followed to raise good crop. Experimental field was laid out in randomized block design with 30 genotypes/lines and replicated thrice. Each block was further subdivided into 30 unit plots. The thirty genotypes were allotted to the 30 unit plots of each block. The plants were raised by 15cm from the ground level to avoid water-logging, if occurred. The each plot size was 2.70 m X 1.20 m, the row–row and plant–plant spacings were kept 45 cm and 30 cm, respectively. All necessary cultural operations were done as and when required during the growing period. Data were recorded on 5 randomly selected plants per entry per replication for various horticultural traits viz., plant height (cm), germination (%), days taken for first flowering, days taken for 50% flowering, number of reproductive branches/plant, pod breadth(cm), pod length (cm), pod width (cm), number of pods/plant, number of pods/cluster, number of clusters/plant, number of branches/plant at maturity, number of seed/pod, pod yield/plant(g), pod yield/plot(kg), 100 seed weight (g), seed yield/plant (g), days to maturity, pod yield (q/ha) and flower colour. The mean data were analyzed for estimation of genotypic and phenotypic coefficient of variation found by **Cockerham, (1963) and Burton, (1952).** Heritability in broad sense and genetic advance were calculated according to the methods of **Allard, (1960).** Simple correlation coefficients among the characters at phenotypic and genotypic levels were analyzed following **Hayes *et al,* (1995), Singh and Chaudhary, (1985).** Path analysis at genotypic level was done following **Dewey and Lu, (1959).** Heritability (h^2) in the broad sense (in percent) was computed by the formula given by **Johnson *et al,* (1955).**

RESULTS AND DISCUSSIONS

The analysis of variance revealed significant differences for the various traits under study, indicating a wide variation among the genotypes. The range mean and other genetic parameters estimated were found a large variation in vegetative growth, yield and quality attributes were noticed among the 30 genotypes of cluster bean (Table 1& 2). Genotypes varied highest mean performance range (55.69-109.02) of plant height (cm) and the lowest mean performance range (0.41-0.78) of pod yield/plot (kg). The tallest genotype IC-415137, while the shortest one was IC-421834. The number of pods/plant was the highest in IC-421834 (76.73) followed by IC-421838 (73.27) and lowest in IC-373427(41.07). The highest number of seeds/pod was obtained from IC421809 (7.53), while in IC-415142(5.93) the least. The highest 100 seed weight (4.23g/100 seed weight) were produced by IC-421855, while the lowest (2.94g/100 seed weight) by IC-421834. Based on the plant height, pod yield/plot, number of pods/plant, number of seeds/pod, 100-seed weight, pods yield (q/ha), the 30 genotypes were grouped as I- high yielders (3 genotypes viz., IC-421855, HG-365 and

IC-421812), where as IC-421834 produced for characters, number of pods/plant, IC-421809 produced for number of seeds/pod and IC-4218855 produced for 100-seeds weight and pod yield (q/ha), II- medium yielders (7genotypes viz., IC-421809, IC-421834, IC-421820, IC-421838, IC-421815, IC-421828, IC-369789,) III- low yielders (9 genotypes viz; IC-415157, IC-369868, IC-311440, IC-415137, IC-373480, VL, IC-421242, IC-370478, IC-421798, IC-402293, IC-415141, IC-421806 and IC-325757) found by **Siddhartha *et al,* (2006).**

The range, mean and other genetic parameters estimated are presented in (Table 3). A wide range of variability was observed for plant height (55.69-109.02 cm), pod yield per plant (79.24-122.17 g), number of pods/plant (41.07-76.73), number of clusters/plant (7.00-31.13), pod yield (120.29-143.50 q/ha) and number of pods/cluster (2.93-21.47). The characters showing wide range of variability have sample scope of selections for the desirable types phenotypic coefficient of variation ranged from (3.55%) for days to maturity to (62.31%) for number of pods/cluster. High phenotypic coefficient of variation was observed for number of pods per cluster (62.31%), number of cluster/plant (43.03%), number of reproductive branches/plant (20.05%) and plant height (17.54%). Genotypic coefficient of variation ranged from 3.09% for germination (%) to 61.52% for number of pods/cluster high genotypic coefficient of variation was observed for number of pods/cluster (61.52%) and number of cluster/plant (41.99%). The magnitude of phenotypic coefficient of variation was in general higher than corresponding genotypic coefficient of variation indicating the influence of environmental factors in their expression. **Johanson *et al,* (1955)** also reported similar result, while studied seven inbreed lines of diverse origin and their 21 hybrids of cluster bean. These results are similar to those of **Hanchinamani, (2004), Dwivedi, (2009) and Malaghan, (2012**), which indicate that greater the genetic variability among the parents, more are the chances of further improvement. This shows more preponderance of environmental factors of yield and yield attributing characters in cluster bean. High heritability (broad sense) was observed for number of pods/cluster (97.50%), number of cluster/plant (95.30%), pod yield/plant g (92.50%), plant height cm (81.50%), days to maturity (79.70%) and number of pods/plant (78.90%), indicating the least influence of environment in their expression, thus suggesting that selection for these traits/ characters based on phenotypic appearance would be reliable. High genetic advance as percentage of mean was observed for number of pods/cluster (125.15%), number of cluster/plant (84.44%) and number of reproductive branches/plant (31.72%). High genetic advance coupled with high heritability could be resulted are in accorandance with the findings of **Liang and Waltre, (1969).** These results are in agreement with the earlier findings of **Dass *et al,* (1973), Gipson and Balakrishnan, (1990) and Saini *et al,* (2010).**

The estimates of genotypic correlation coefficients in general were higher in magnitude than phenotypic correlation coefficients (Table 4), indicating the more preponderance of heritable components. Plant height was positively and significantly correlated (genotypic and phenotypic) with number of branches/plant at maturity (0.428; 0.243), 100-seed weight (0.379; 0.271) and Seed yield/plant (0.417; 0.371), pod yield (q/ha) were positively and significantly correlated with plant height (genotypic). Germination percentage was positively and significantly correlated (genotypic and phenotypic) with pod length (0.665; 0.134) and number of pods/plant (0.504; 0.326), pod yield q/ha were positively and significantly correlated with days to maturity (genotypic). Number of reproductive branches/plant were positively and significantly correlated with (genotypic and phenotypic) with number of pods/cluster (0.646; 0.530), number of branches/plant at maturity (0.244; 0.220) and number of seed/pod (0.489; 0.213), green pod yield (q/ha) were positively and significantly correlated with number of reproductive branches/plant (genotypic). Number of seeds/pod was positively and significantly correlated with (genotypic and phenotypic) pod yield/plant (0.582; 0.336) and seed yield/plant, pod yield q/ha were positively and significantly correlated with number of seeds/pod (genotypic). Pod yield/plant was positively and

significantly correlated with (genotypic and phenotypic) pod yield /plot (0.445; 0.379), seed yield/plant (g) and days to maturity, pod yield/plant (g) were positively and significantly correlated with pod yield (q/ha) (genotypic). **Shah *et al,* (1990),** observed between pod yield and pod length. **Singh *et al,* (2000), Shinde and Dumare, (2001), Rai *et al,* (2001) and Atilla, (2007),** observed between pod yield, plant height, pod length, pod width, pod weight and number of seeds/pod at both genotypic and phenotypic level. Plant height with days to 50% flowering (-0.467; -0.362) and number of pod/plant (-0.115; -0.127) were negatively and significantly correlated. Pod length with number of branches/plant at maturity (-0.917; -0.138) were negatively and significantly correlated was reported by **Saha *et al,* (1986) and Kumarswamy, (1990)** also reported days to 50% flowering to be negatively associated with pod width and pod breath.

The characters showing significantly correlation were subjected to estimation of direct and indirect effects (Table 5). Data depicted that number of reproductive branches/plant (0.208; 0.149), pod breadth (0.088; 0.007), pod width (0.032; 0.011), number of pods/cluster (0.055; 0.008), number of clusters/plant (0.048; 0.005), number of seed/pod (0.311; 0.160), pod yield/plant (0.043; 0.040), pod yield/plot (0.004; 0.001) and seed yield/plant (0.347; 0.044). Expected high positively direct and indirect effect is pod yield (q/ha). The direct and indirect effects of remaining characters were poor in magnitude. Seed yield/plant (0.347; 0.044) showed high direct and indirect effects on pod yield (q/ha) via number of seed/pod (0.311; 0.160). These findings in agreement with **Baswana *et al,* (1980) and Biju *et al,* (2001)** in Indian bean, **Rai *et al,* (2004)** in french bean and **Patil *et al,* (1989)** in cowpea.

CONCLUSIONS

On the basis of above findings, it can be concluded that the characters like- number of pods/cluster, number of clusters/plant, number of reproductive branches/plant, plant height (cm) and pod yield/plot (kg), showed high genotypic coefficient of variation as well as high phenotypic coefficient of variation with genetic advance, indicating there by that selections based on phenotypic performance could be effective for improvement of these characters. From the present studies it can be also concluded that characters like 100 seed weight, plant height, pod yield/plot, pod yield/plant and pod yield (q/ha), showing higher values of genotypic coefficient of variation, heritability (broad-sense) and genetic advance can be improved by selections. Further, correlation and path analysis revealed that number of pods/plant, pod width, number of branches/plant at maturity, pod length, and pod yield/plant are good indicators on pod yield (q/ha) in cluster bean and are effective selection parameters for development of productive genotypes in cluster bean.

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Table 1: Mean Performance of Growth and Growth Attributing Traits in 30 Cluster bean Genotypes

Characters / Genotypes	1	2	3	4	5	6	7	8	9	10	11
IC-258087	68.32	87.18	22.12	34.83	4.87	3.64	6.01	5.72	45.53	7.60	10.47
IC-258092	72.91	91.49	23.66	34.19	5.07	3.46	5.62	5.77	52.33	7.07	9.61
IC-28272	73.53	93.80	22.83	34.83	4.87	3.60	5.13	6.18	60.00	5.93	7.27
IC-311440	70.94	94.59	19.77	33.48	4.60	4.00	5.48	6.02	61.47	6.40	9.27
IC-311441	75.38	92.57	20.07	32.76	4.27	4.34	5.30	6.18	57.80	4.27	7.00
IC-325757	78.00	91.19	20.32	34.61	5.60	4.27	6.17	6.13	54.87	4.93	9.40
IC-329038	82.76	87.82	20.65	33.47	4.73	3.93	5.76	5.77	49.87	4.23	8.00
IC-369789	97.67	89.52	21.74	33.03	5.60	3.73	6.15	5.85	52.93	5.93	17.40
IC-369868	68.82	85.80	22.83	33.08	4.53	3.92	5.47	6.11	51.73	5.53	16.07
IC-370478	104.96	95.08	23.48	34.17	6.00	3.55	5.57	5.98	64.96	5.27	13.67
IC-370490	73.93	95.38	23.74	35.04	4.47	3.90	5.95	6.29	47.93	5.27	12.40
IC-373427	78.62	88.16	22.43	34.48	5.73	3.67	6.90	6.23	41.07	5.40	14.67
IC-373480	73.38	87.90	22.78	33.83	6.80	3.67	5.23	6.05	58.00	4.33	31.13
IC-402293	86.74	89.53	21.17	31.84	5.73	3.85	5.69	6.10	55.27	5.93	23.87
IC-415137	109.02	97.25	22.51	32.84	7.40	3.77	6.24	6.20	65.67	13.07	8.73
IC-415142	85.95	94.95	22.54	33.52	7.40	3.95	6.62	5.84	65.40	21.47	10.20
IC-415157	63.55	90.87	21.44	33.60	6.80	3.94	5.58	5.95	58.53	19.67	11.67
IC-415159	67.43	87.22	23.34	33.08	7.40	3.74	5.65	5.85	52.93	2.93	8.87
IC-421242	80.44	92.93	23.55	33.24	7.93	3.87	5.85	6.10	60.33	13.07	8.73
IC-421798	98.49	90.55	22.98	34.13	6.47	3.96	5.52	5.95	53.60	9.33	13.87
IC-421806	89.20	90.58	22.32	31.64	5.60	3.80	5.87	6.34	54.93	11.00	12.33
IC-421809	92.50	94.49	21.38	34.33	5.75	3.38	5.57	5.70	46.80	5.41	9.33
IC-421812	77.19	95.53	23.04	36.95	6.70	3.65	6.16	6.03	53.00	6.04	9.97
IC-421815	74.68	90.24	22.31	34.71	6.60	3.52	5.29	5.81	47.33	5.47	15.34
IC-421820	71.17	89.56	21.52	35.15	4.49	3.65	6.38	5.87	54.67	6.02	11.15
IC-421828	69.67	87.56	21.95	37.79	6.26	3.57	4.95	5.98	63.13	6.70	10.27
IC-421834	55.69	91.50	21.39	36.41	5.18	3.79	5.99	5.85	76.73	5.34	12.20
IC-421838	65.88	94.25	22.55	35.11	4.20	3.53	5.32	5.82	73.27	5.50	12.70
IC-421855	96.82	90.28	22.40	33.44	6.21	3.29	4.52	5.70	56.79	5.07	7.48
HG-365	97.19	85.86	22.09	33.61	6.93	4.19	5.79	5.98	49.95	5.31	7.72
F-value	**	**	**	*	*	*	*	**	**	**	*
GM	80.02	91.12	22.16	34.10	5.80	3.77	5.72	5.97	56.22	7.91	12.02
Range	55.69-109.02	85.80-97.25	19.77-23.74	31.64-37.79	4.20-7.93	3.29-4.34	4.52-6.90	5.70-6.34	41.07-76.73	2.93-21.47	7.00-31.13
SEm±	4.92	2.06	0.974	0.765	0.457	0.301	0.344	0.275	3.20	0.640	0.919
CD (p=.05)	10.07	4.21	1.99	1.56	0.937	0.616	0.705	0.564	6.56	1.31	1.88

*** Significance at 5% level; ** significance at 1% level**

1. Plant height (cm) 2. Germination (%) 3. Days taken for first flowering 4. Days taken for 50% flowering
5. Number of reproductive branches/plant 6. Pod breath (cm) 7. Pod length (cm) 8. Pod width (cm)
9. Number of pods/plant 10. Number of pods /cluster 11. Number of clusters /plant

Table 2: Mean Performance of Growth and Yield Attributing Traits in 30 Cluster Bean Genotypes

Characters / Genotypes	12	13	14	15	16	17	18	19	20
IC- 258087	10.00	6.33	88.12	0.51	3.77	6.13	94.80	120.37	
IC-258092	8.40	6.47	84.04	0.55	4.03	6.41	91.60	122.65	
IC-28272	8.20	5.94	82.98	0.51	3.35	5.80	90.07	122.09	
IC-311440	8.60	6.53	84.88	0.57	3.47	5.26	88.80	127.45	Purplish white
IC-311441	7.93	6.60	86.57	0.51	3.69	5.10	90.93	123.10	Purplish white
IC-325757	8.53	7.27	79.24	0.53	3.43	6.24	86.73	124.55	Purple
IC-329038	8.80	6.07	87.70	0.59	3.06	6.76	87.07	121.09	Purplish white
IC-369789	9.00	6.33	88.75	0.49	3.83	5.75	95.67	129.25	Purple
IC-369868	7.73	6.00	90.45	0.60	4.09	7.24	96.67	128.04	White
IC-370478	7.53	6.60	85.60	0.50	3.69	7.72	92.53	125.10	Purplish white
IC-370490	7.93	6.53	97.81	0.61	3.65	7.01	90.53	121.53	Purplish white
IC-373427	8.07	6.40	92.80	0.67	3.12	7.04	97.40	129.17	Purplish white
IC-373480	8.20	6.53	91.68	0.53	3.53	6.35	94.13	126.25	Purple
IC-402293	8.07	6.40	86.32	0.46	3.17	6.94	91.93	124.49	Purplish white
IC-415137	10.13	7.00	86.35	0.73	3.97	7.04	97.47	127.12	Purplish white
IC-415142	8.60	5.93	97.59	0.65	3.51	6.94	92.20	124.30	Purplish white
IC-415157	8.87	7.40	92.78	0.56	3.39	6.09	91.47	128.76	Purplish white
IC-415159	8.00	7.20	90.49	0.41	3.80	7.55	90.13	120.29	Purplish white
IC-421242	8.33	7.00	100.35	0.49	3.47	5.75	90.33	126.22	Purplish white
IC-421798	7.87	7.07	101.97	0.51	3.50	7.76	91.40	124.81	White
IC-421806	8.20	7.33	98.31	0.49	3.59	8.29	89.07	124.21	Purplish white
IC-421809	9.13	7.53	120.40	0.58	3.83	7.97	94.53	134.08	Purplish white
IC-421812	8.60	6.93	122.17	0.53	3.71	6.34	93.87	136.99	Purplish white
IC-421815	8.07	7.13	107.36	0.73	3.49	7.75	90.33	132.08	Purplish white
IC-421820	8.60	6.40	103.85	0.58	3.40	7.20	93.80	132.89	Purple
IC-421828	7.67	6.47	104.75	0.78	2.94	7.51	96.67	130.80	White
IC-421834	7.67	6.93	111.64	0.57	3.33	7.01	92.13	133.91	Purplish white
IC-421838	7.13	7.20	116.54	0.71	3.46	7.05	91.53	132.26	Purplish white
IC-421855	8.73	7.07	116.65	0.74	4.23	8.93	97.87	143.50	Purplish white
HG-365	9.00	7.07	116.50	0.63	4.21	8.92	96.13	138.97	Purplish white
F-value	*	*	*	**	*	*	**	**	Purple
GM	8.38	6.72	97.15	0.57	3.59	6.92	92.59	127.87	
Range	7.13-10.13	5.93-7.53	79.24-122.17	0.41-0.78	2.94-4.23	5.10-8.93	86.73-97.87	120-29-143.50	
SEm±	0.434	0.348	2.84	0.00396	0.243	0.471	1.20	4.67	
CD (p= .05)	0.890	0.714	5.82	8.12	0.499	0.965	2.47	9.56	

*** Significance at 5% level; ** significance at 1% level**

12. Number of branches /plant at maturity
13. Number of seed /pod
14. Pod yield /plant (g)
15. Pod yield /plot (kg)
16. 100 Seed weight (g)
17. Seed yield /plant (g)
18. Days to maturity
19. Pod yield (q/ha)
20. Flower colour

Table 3: Range, Mean, Genetic Variability, Heritability in Broad Sense, Genetic Advance and Genetic Advance as Percent of Mean of different Characters in Cluster Bean

S.No.	Characters	General Mean	SEm±	Range		Co-efficient of variation			Heritability in broad sense (%)	Genetic advance (GA)	Genetic advance as % of mean
				Min.	Max.	CV (%)	PCV (%)	GCV (%)			
1	X1	80.02	4.92	55.69	109.02	7.53	17.54	15.84	81.50	23.58	29.46
2	X2	91.12	2.06	85.80	97.25	2.76	4.15	3.09	55.40	4.31	4.73
3	X3	22.16	0.974	19.77	23.74	5.38	6.48	3.60	30.90	0.91	4.10
4	X4	34.10	0.765	31.64	37.79	2.74	4.54	3.61	63.30	2.02	5.92
5	X5	5.80	0.457	4.20	7.93	9.66	20.05	17.57	76.80	1.84	31.72
6	X6	3.77	0.301	3.29	4.34	9.77	10.32	3.30	10.20	0.08	2.12
7	X7	5.72	0.344	4.52	6.90	7.37	10.53	7.52	51.00	0.63	11.01
8	X8	5.97	0.275	5.70	6.34	5.64	5.67	0.53	9.00	0.01	0.16
9	X9	56.22	3.20	41.07	76.73	6.98	15.20	13.50	78.90	13.89	24.70
10	X10	7.91	0.640	2.93	21.47	9.90	62.31	61.52	97.50	9.90	125.15
11	X11	12.02	0.919	7.00	31.13	9.36	43.03	41.99	95.30	10.15	84.44
12	X12	8.38	0.434	7.13	10.13	6.35	9.44	6.99	54.80	0.89	10.62
13	X13	6.72	0.348	5.93	7.53	6.35	8.57	5.75	45.00	0.53	7.88
14	X14	97.15	2.84	79.24	122.17	3.58	13.11	12.61	92.50	24.28	24.99
15	X15	0.57	0.00396	0.41	0.78	8.42	17.32	15.14	76.40	0.16	28.07
16	X16	3.59	0.243	2.94	4.23	8.31	11.23	7.54	45.10	0.37	10.30
17	X17	6.92	0.471	5.10	8.93	8.33	15.45	13.02	70.90	1.56	22.54
18	X18	92.59	1.20	86.73	97.87	1.59	3.55	3.17	79.70	5.40	5.83
19	X19	127.87	4.67	120.29	143.50	4.47	5.79	3.67	40.30	6.14	4.80

Table 4: Estimates of Genotypic and Phenotypic Correlation Coefficients of different Characters in Cluster Bean

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	G	0.245*	0.207*	-0.467**	0.435**	-0.154	0.134*	0.449*	-0.115	-0.028	-0.035	0.428*	0.115	0.012	0.050	0.379*	0.417*	0.301*	0.117*
	P	0.185	0.055	-0.362*	0.025	0.025	-0.003	0.028	-0.127	-0.019	-0.027	0.243*	0.126*	0.020	0.050	0.271*	0.371*	0.240*	0.096*
2	G		0.202*	0.087	-0.003	-0.358*	0.167*	0.876**	0.504*	0.131	-0.316*	0.103	0.197*	0.074	0.063	0.014	-0.328*	-0.259*	-0.102*
	P		0.005	0.092	0.058	0.036	0.049	0.117	0.326*	0.085	-0.219*	-0.025	0.125	0.054	0.059	0.059	-0.143	-0.150	0.048*
3	G		rg	0.297	0.498**	-1.245**	-0.046	1.015	-0.077	0.317*	0.118	-0.258	-0.013	0.220*	-0.041	0.399*	0.405*	0.304*	-0.117*
	P			-0.039	0.247	-0.180	0.033	-0.033	-0.035	0.164*	0.121	-0.151	-0.024	0.105	0.028	0.251	0.213	0.197*	-0.035*
4	G			rg	-0.149	-0.649**	0.021	-1.586**	0.164*	-0.309	-0.155*	-0.280	0.010	0.450*	0.391*	-0.443*	0.015	0.149	0.421**
	P				-0.070	-0.188	-0.074	-0.060	0.145	-0.237	-0.153*	-0.131	-0.057	0.390*	0.300*	-0.170	-0.028	0.147	0.198*
5	G				rg	0.010	0.112	-0.175	0.035	0.646**	0.063	0.244*	0.489*	0.199*	0.054	0.149	0.292*	0.218*	0.218*
	P					-0.058	0.081	-0.005	0.075	0.530**	0.051	0.220*	0.213*	0.157	0.002	0.086	0.193	0.153	0.106*
6	G					rg	0.665**	3.421**	0.115*	0.268*	0.211*	0.344*	-0.171	-0.679**	-0.645**	-0.290*	-0.632**	-0.878**	-0.831**
	P						0.134*	0.261	-0.048	0.095	-0.073	-0.141	0.001	-0.232*	-0.145*	-0.015	-0.225*	-0.183	-0.135*
7	G						rg	1.115**	-0.211	0.268*	-0.017	0.390*	-0.192	-0.157	-0.208*	-0.248*	-0.160	0.058	-0.209*
	P							0.119	-0.155	0.208*	0.023	0.204*	-0.107	-0.119	-0.089	-0.029	-0.160	-0.034	-0.161*
8	G							rg	-0.234*	-0.201	0.929**	-0.917**	-1.039**	-1.696**	-1.160**	0.022	-0.921**	-0.578**	-2.860**
	P								0.013	-0.025	0.040	-0.138	0.046	-0.228*	-0.029	-0.214	-0.136	-0.078	-0.032*
9	G								rg	0.195*	0.048	-0.401*	0.086	0.077	0.159*	0.230*	-0.144	-0.106	0.130*
	P									0.149	-0.040	-0.178	0.031	0.056	0.084	-0.096	-0.105	-0.077	0.080*
10	G									rg	-0.196*	0.215*	0.210*	-0.120	-0.164*	0.029	-0.020	-0.122	-0.339*
	P										-0.186*	0.144	0.141*	-0.106	-0.124	0.025	-0.006	-0.109	-0.195*
11	G										rg	-0.288*	-0.195*	-0.138	-0.176*	-0.232*	-0.036	0.152	-0.100*
	P											-0.207	-0.118	-0.132	-0.133	-0.129	-0.019	0.145	-0.060*
12	G											rg	0.100	-0.123	0.059	0.406*	-0.094	0.318*	0.099*
	P												-0.016	-0.069	0.003	0.296*	-0.089	0.179	-0.008*
13	G												rg	0.582**	0.045	0.318*	0.424*	-0.123	0.562**
	P													0.336*	0.007	0.109	0.295*	-0.082	0.218*
14	G													rg	0.445*	0.186*	0.573**	0.341*	0.997*
	P														0.379*	0.129	0.515**	0.311*	0.588*
15	G														rg	-0.028	0.431*	0.505**	0.708**
	P															0.014	0.316*	0.390*	0.351*
16	G															rg	0.361*	0.458*	0.431**
	P																0.202	0.303*	0.134*
17	G																rg	0.391*	0.612**
	P																	0.274	0.332*
18	G																	rg	0.745**
	P																		0.329*

***and** indicate significant of values at P=0.05 and 0.01, respectively**

1. Plant height (cm) 2. Germination (%) 3. Days taken for first flowering
4. Days taken for 50% flowering
5. Number of reproductive branches/plant 6. Pod breath (cm) 7. Pod length (cm) 8. Pod width (cm)
9. Number of pods/plant 10. Number of pods /cluster 11. Number of clusters /plant
12. Number of branches /plant at maturity 13. Number of seed /pod 14. Pod yield /plant (g) 15. Pod yield /plot (kg)
16. 100 Seed weight (g) 17. Seed yield /plant (g) 18. Days to maturity 19. Pod yield (q/ha

Table 5: Genotypic and Phenotypic Path Coefficient Effect of different Characters in Cluster Bean

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	G	**-0.186**	-0.002	-0.013	0.147			0.007		0.015	0.010	-0.071	0.055	0.007	0.005	-0.068	-0.058	0.267	
	P	**-0.047**	0.006	-0.007	0.044			0.000		0.004	0.001	-0.006	0.006	0.010	0.005	0.011	0.001	0.038	0.117*
2	G	-0.046	**-0.006**	-0.013	-0.027	0.090	-0.014	0.009	-0.014	-0.071	0.089	-0.017	0.094	0.039	0.006	-0.002	0.045	-0.230	0.096*
	P	-0.009	**0.034**	-0.001	-0.011	0.038	0.000	-0.002	-0.008	-0.019	0.010	0.001	0.006	0.025	0.006	0.002	0.000	-0.024	-0.102*
3	G	-0.039	-0.001	**-0.064**	-0.094	-0.001	-0.032	-0.003	0.061	-0.173	-0.033	0.043	-0.006	0.117	-0.004	-0.059	-0.056	0.270	0.048*
	P	-0.003	0.000	**-0.126**	0.005	0.009	0.000	-0.001	0.021	-0.036	-0.005	0.004	-0.001	0.050	0.003	0.010	0.001	0.031	-0.117*
4	G	0.087	-0.001	-0.019	**-0.315**	0.103	-0.110	0.001	-0.009	0.169	0.044	0.047	0.005	0.240	0.037	0.065	-0.002	0.132	-0.035*
	P	0.017	0.003	0.005	**-0.121**	0.037	-0.001	0.003	-0.002	0.052	0.007	0.003	-0.003	0.185	0.032	-0.007	0.000	0.023	0.421**
5	G	-0.031	0.000	-0.032	0.047	-0.031	-0.057	0.006	0.020	-0.352	-0.018	-0.041	0.233	0.106	0.005	-0.022	-0.040	0.193	0.198*
	P	-0.012	0.002	-0.031	0.008	-0.011	-0.001	-0.003	0.009	-0.116	-0.002	-0.006	0.009	0.075	0.000	0.003	0.001	0.024	0.218*
6	G	0.029	0.001	0.079	0.205	**0.208**	0.001	0.037	0.004	-0.135	0.060	-0.057	-0.081	-0.362	-0.062	0.043	0.088	-0.780	0.106*
	P	-0.001	-0.001	0.023	0.023	**0.149**	0.000	-0.006	0.005	-0.021	0.003	0.004	0.000	-0.110	-0.015	-0.001	-0.001	-0.029	-0.831**
7	G	-0.025	0.002	0.003	-0.007	0.002	**0.088**	0.055	0.014	-0.146	0.005	-0.065	-0.091	-0.084	-0.020	0.037	0.022	0.052	-0.135*
	P	0.000	0.002	-0.004	0.009	-0.009	**0.007**	-0.043	-0.003	-0.045	0.001	-0.005	-0.005	-0.057	-0.009	-0.001	-0.001	-0.005	-0.209*
8	G	0.023	-0.009	-0.006	0.011	0.023	0.059	**0.016**	-0.026	0.108	0.009	0.063	0.057	0.068	0.018	0.032	-0.025	0.075	-0.161*
	P	0.003	-0.003	0.006	0.013	0.012	0.001	**0.005**	-0.010	0.038	-0.003	0.004	0.002	0.0045	0.007	0.003	0.002	0.004	-2.860**
9	G	0.021	0.011	0.005	-0.052	0.021	0.045	-0.012	0.032	-0.106	0.014	0.067	0.041	0.041	0.015	0.034	0.020	-0.094	-0.032*
	P	0.006	-0.001	0.004	-0.018	0.009	-0.002	0.007	0.011	-0.032	0.002	0.005	0.001	0.027	0.009	-0.004	0.000	-0.012	0.130*
10	G	0.005	0.003	-0.020	0.097	0.007	0.010	0.015	**0.121**	**-0.545**	0.055	-0.036	0.100	-0.064	-0.016	-0.004	0.003	-0.108	0.080*
	P	0.001	0.002	-0.021	0.029	0.011	0.000	-0.009	**0.064**	**-0.218**	0.008	-0.004	0.006	-0.050	-0.013	0.001	0.000	-0.017	-0.339*
11	G	0.007	-0.007	-0.008	0.049	0.134	0.022	-0.001	0.024	0.107	**-0.283**	0.048	-0.093	-0.074	-0.017	0.034	0.005	0.135	-0.195*
	P	0.001	-0.001	-0.015	0.018	0.079	0.001	0.001	0.009	0.041	**-0.045**	0.005	-0.005	-0.062	-0.014	-0.005	0.000	0.023	-0.100*
12	G	-0.080	-0.001	0.016	0.088	0.013	-0.019	0.0121	-0.006	-0.117	0.081	**-0.166**	0.048	-0.065	0.006	-0.060	0.013	0.283	-0.060*
	P	-0.011	-0.001	0.019	0.016	0.008	-0.001	-0.009	-0.003	-0.031	0.009	**-0.026**	-0.001	-0.033	0.000	0.012	0.000	0.029	0.099*
13	G	-0.021	0.004	0.001	-0.003	0.051	0.030	-0.011	-0.049	-0.114	0.055	-0.017	**0.476**	0.311	0.004	-0.047	-0.059	-0.109	-0.008*
	P	-0.006	0.000	0.003	0.007	0.033	-0.001	0.005	-0.011	-0.031	0.005	0.000	**0.044**	0.160	**0.533**	0.001	0.001	-0.013	0.562**
14	G	-0.002	0.002	-0.014	-0.142	0.102	-0.015	-0.009	0.010	0.065	0.039	0.020	0.277	0.043	0.001	-0.027	-0.079	0.302	0.218*
	P	-0.001	0.000	-0.013	-0.047	0.032	0.000	0.005	0.002	0.023	0.006	0.002	0.015	**0.474**	0.004	0.005	0.002	0.050	0.997**
15	G	-0.009	0.002	0.003	-0.123	0.041	-0.060	-0.011	0.009	0.089	0.050	-0.010	0.021	0.237	**0.096**	0.004	-0.060	0.448	0.588**
	P	-0.002	0.000	-0.004	-0.036	0.023	-0.002	0.004	0.004	0.027	0.006	0.000	0.000	0.180	**0.106**	0.001	0.001	0.062	0.708**
16	G	-0.085	0.002	-0.025	0.140	0.001	-0.057	0.004	0.019	-0.016	0.065	-0.068	0.151	0.099	-0.003	**-0.148**	-0.050	0.407	0.351*
	P	-0.013	0.002	-0.032	0.020	0.000	-0.001	0.001	0.005	-0.005	0.006	-0.008	0.005	0.061	0.002	**0.039**	0.001	0.048	0.431**
17	G	-0.078	-0.005	-0.026	-0.005	0.031	-0.026	-0.009	-0.028	0.011	0.010	0.016	0.202	0.306	0.041	-0.053	**-0.138**	0.347	0.134*
	P	-0.017	0.002	-0.027	0.003	0.013	0.000	0.007	-0.006	0.001	0.001	0.002	0.013	0.244	0.034	0.008	**0.003**	0.044	0.612**
18	G	-0.056	-0.005	-0.019	-0.047	0.061	-0.056	0.003	-0.017	0.067	-0.043	-0.053	-0.058	0.182	0.048	-0.068	-0.054	**0.888**	0.332*
	P	-0.011		-0.025	-0.018	0.029	-0.002	0.001	-0.007	0.024	-0.006	-0.005	-0.004	0.148	0.041	0.012	0.001	**0.159**	0.745**
						0.045	-0.078		-0.013										0.329*
						0.023	-0.001		-0.005										

*and** indicate significant of values at P=0.05 and 0.01, respectively

Residual value: (Genotypic - 0.3944 and phenotypic - 0.5653) **Bold figures indicate direct effects.**

1. Plant height (cm) 2. Germination (%) 3. Days taken for first flowering 4. Days taken for 50% flowering
5. Number of reproductive branches/plant 6. Pod breath (cm) 7. Pod length (cm) 8. Pod width (cm)
9. Number of pods/plant 10. Number of pods /cluster 11. Number of clusters /plant
12. Number of branches /plant at maturity 13. Number of seed /pod 14. Pod yield /plant (g) 15. Pod yield /plot (kg)
16. 100 Seed weight (g) 17. Seed yield /plant (g) 18. Days to maturity 19. Pod yield (q/ha)